REMARKS

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Claim 1 has been amended to recite $0.003\% \leq S \leq 0.2\%$. Support for this amendment is found on page 14, line 4 of Applicants' specification. No new matter has been added to the application by this amendment.

The rejection of claim 1 under 35 U.S.C. § 112, second paragraph, as being indefinite is respectfully traversed.

The Examiner states that the term "da" is indefinite and needs to be clearly defined. However, "daN" is a usual abbreviation of SI units, meaning "decanewton" or "dekanewton", that is 10 newtons. "Decinewton" would be abbreviated as "dN".

The unit "daN" is frequently used in metallurgy for expressing mechanical properties of materials and would be clearly understood by one of ordinary skill in the art. Enclosed herewith are print-outs from the Internet demonstrating that daN is a known abbreviation for decanewton.

Thus, the Examiner is respectfully requested to withdraw the rejection.

The rejection of claims 1, 6-13 and 15-17 under 35 U.S.C. § 103(a) as being unpatentable over Bellus et al. in view of Bone or Vodopyanov et al. is respectfully traversed.

The Examiner takes the position that Bellus disclose forged bainitic steel alloy parts having an analogous composition which can be fabricated for automobile components, such as shafts, and are produced in essentially the same manner as claimed by Applicants.

The Examiner states that even though machining is not disclosed, such would be obvious to incorporate since other analogous examples teach machining.

The Examiner also states that even though deep rolling the forged part at locations that are to be subjected to particularly high levels of stress to generate high compressive stresses is not taught by Bellus, such would not be a patentable difference. The Examiner relies upon Bone and Vodopyanov as teaching that it is a conventional practice in the

metallurgical art to subject crankshafts in the fillet area to deep rolling in order to generate residual compressive stress to thereby improve fatigue strength.

First, as stated above, Bone and Vodopyanov are relied upon solely to show deep rolling.

Vodopyanov describes a very particular device for performing a deep rolling on crankshafts. Its advantage is to avoid lateral movements which could damage the counterweights and adjacent parts on a crankshaft, the nature of which is not specified, and could damage the rolling tools, the crankshaft itself. (See, for example, column 1, lines 9-28 and column 1, line 62 to column 2, line 29.) The particularities of this device only concern the inferior part of a deep rolling device, while the upper part of the machine is of a conventional type. (See column 2, lines 4-6.)

<u>The nature of the rollers of Vodopyanov is not specified</u>. This parameter is very important for obtaining a good result of the deep rolling step. T<u>he material in which the treated crankshaft is or can be made is not specified</u>, either. It must be recalled that crankshafts can be made in different materials, according to the type of vehicles in which they will be used. Different kinds of steels, but also pig iron or aluminum (for small engines like motorcycles, scooters and so on) can be used. Vodopyanov might, admittedly, be used for crankshafts made of steel, but the reference fails to mention for which precise kind of steel it is intended to be used, if any.

Also, Vodopyanov gives no indication about the load applied by the rollers.

Thus, Vodopyanov could be used by the Examiner <u>only</u> to demonstrate that, generally speaking, deep rolling of the fillets of a crankshaft was known before the invention was made.

However, Applicants do not assert that they invented deep rolling of crankshaft fillets. (See the introduction of the application.) The invention, as recited in claim 1, relies on a <u>combination</u> of three items: a precise <u>steel composition</u>, a precise <u>succession of thermal and thermomechanical treatments for fabricating a part</u> (which can be a crankshaft, but also another kind of part) and the <u>use of deep rolling for reinforcing some highly stressed portions of the part within a precise range of applied loads</u>.

Bone also describes a very particular type of roll hardening machine for crankshaft parts. Again, the material of the treated crankshaft is not specified; nor is the material of the rollers.

Bone speaks of applied loads of 12 kN and 6 kN (1200 daN and 600 daN) in column 5, lines 14-18. However, it must be remarked that in this particular machine, the pressure applied by the rollers is varied or pulsed between these limits during the deep rolling operation according to the circumferential position of the rollers on the fillets, as explained in particular in the cited passage and in claim 7. This is not normally so in the invention, where the applied load may very well remain constant over several rotations of the crankshaft, like in conventional deep rolling processes. See page 12, lines 8-11 of the Applicants' specification, where it is said that the test pieces were subjected to deep rolling "under conditions analogous to that of deep rolling conventionally performed on the fillets connecting the crankpins of a crankshaft."

The citation of 600 and 1200 daN loads in Bone only shows that these loads are possibly used during a deep rolling operation of a crankshaft made of an unspecified material, performed on the precise machine described in Bone. But there is no suggestion that these loads would be of universal use, for any crankshaft made of any material, during a conventional deep rolling operation where the load could remain constant during several turns of the crankshaft.

Note also that <u>the invention excludes the possibility to have an applied load between 600 and 800 daN</u>, while such loads could be used in the described example of Bone on some circumferential positions of the rollers.

Therefore, Bone can be used only to demonstrate that deep rolling of crankshaft fillets was known before the present invention was made, but gives no indication that the <u>precise combination of claim 1</u> (which is not limited to crankshafts but may concern any type of part for which a deep rolling of some portions is useful) would be obvious.

Vodopyanov and Bone, consequently, do not bring significant new elements which would show that the invention would have been obvious in view of the prior art already admitted by the applicant.

The following discussion highlights the distinctions between the teachings of Bellus et al. and the invention. These distinctions are intended to show that one of ordinary skill in the art would not arrive at Applicants' invention from the teachings of Bellus et al., because Bellus et al. do not recognize the importance of the particular steel composition recited by Applicants. Thus, a steel made in accordance with the teachings of Bellus et al. would not fulfil the requirement of Applicants' invention, as discussed in detail below.

B is not compulsory in Bellus et al., contrary to Applicants' invention (5-50 ppm). This is confirmed by the Example set forth in column 4 of Bellus et al., where B is explicitly absent. In the examples of the present application, the reference example on page 12, lines 12-16 contains no B, while both examples according to the invention (page 12, lines 32 to 36 and page 14, lines 2-7) contain 30 ppm of B.

B is <u>compulsory</u> in Applicants' invention, because it helps to displace the ferrite field to the right of the TRC diagram. [See enclosed Document (1). Applicants note that this document was prepared for related application U.S. 10/724,641, but it is qualitatively valid for the present invention.] Displacing the ferrite field to the right of the TRC diagram allows for more surely <u>avoiding the formation of ferrite</u> during the slow cooling step following forging, in the temperature range of 600-300°C, <u>so that a 100% bainite structure is obtained</u>. In Bellus et al., as seen above, such a presence of ferrite is quite acceptable, provided it remains under 20% of the structure.

Therefore, B may be present, but its absence is accepted, as demonstrated by the Example in column 4 of the reference. However, in Applicants' invention, <u>the mere presence of B is not sufficient for surely obtaining the desired effect</u>. It is necessary that at least the biggest part of B be present in solid solution, in other words in an uncombined state in the matrix, that is not combined with N and C as nitrides or carbonitrides. As explained in Applicants' specification, when Ti $\geq$ 3.5 N, all of the dissolved Ni is captured, thus avoiding the formation of boron nitrides or carbonitrides. (See page 8, lines 26-31 of Applicants' specification.) It appeared to the inventors that <u>the displacement of the ferrite field is obtained only by the uncombined B</u>, which segregates at the grain boundaries and prevents the germination of ferrite during cooling, or belates

this germination so that it can occur only when the cooling is extremely slow, and not in the usual industrial conditions.

To this end, the presence of Ti is also compulsory in the invention, contrary to the teachings of Bellus et al. Although Ti is cited in the examples of Bellus et al., since the N content is not mentioned, it is impossible to determine if Ti ≥ 3.5 N. Applicants' claims require 0.005-0.04% Ti, and the components must satisfy Ti ≥ 3.5 N. (See page 8, lines 31-36.) As discussed above, the whole N is captured by Ti which forms TiN, avoiding the formation of boron nitrides or carbonitrides. Therefore, B can fully play its part, as explained above, by displacing the ferrite field to the right part of the diagram, and thus, avoiding the presence of ferrite. On the contrary, ferrite phase is quite tolerated in Bellus et al., provided it remains under 20%.

Applicants acknowledge that the first example in the specification contains Ti, but the condition Ti ≥ 3.5 N is not fulfilled, and Ti is not present in the second example in the specification. However, Applicants previously provided a Supplementary Example with the response of July 3, 2006, which is fully in accordance with Applicants' claim 1. The description of the Supplementary Example is restated below for the Examiner's convenience.

SUPPLEMENTARY EXAMPLE 1

Trials were performed on examples of a steel having a 100% bainitic structure, corresponding to the second implementation of the invention as described on page 11, lines 3-25 of Applicants' specification. The composition of this steel was C=0.299%; Mn=1.478; Si=1.160%; Ni=0.169%; Cr=0.870%; Mo=0.104%; V=0.114%; Cu=0.963%; Nb=0.052; B=30ppm; Ti=0.028%; N=70ppm, which gives Ti/N=4, so >3.5; S=0.024%; and Al=0.021%. After forging and cooling in still air at 0.5 to 1°C/s, 100% bainitic structure was obtained and no further tempering or annealing was performed.

A remarkably high tensile strength of 1197 MPa was obtained, as well as a remarkably high yield strength of 766 MPa. These values are much higher than those for the reference steel described on page 12, lines 12-31 (860 MPA tensile strength and 570 MPa yield strength). After deep rolling the sample in the same conditions as the reference steel, also with applied loads of 800-1200 daN, cracking started to occur for moments of

2150 to 2220 N.m, and rupture moments were 5600 to 5880 N.m. These are significantly better values than for the reference steel. (See page 12, lines 26-31.) Specifically, the improvement for the cracking starting moment is 12% and 32% for the rupture moment.

Further, Nb is not compulsory in Bellus et al., and is cited in none of its examples. However, in Applicants' claim 1, Nb is present with a content 0.005-0.06%.

Although none of the examples of Applicants' specification contain Nb, the following Supplementary Example 2 is provided.

SUPPLEMENTARY EXAMPLE 2

The tested steel had the composition C = 0.295%; Mn = 1.478%; Si = 1.160%; Ni = 0.169%; Al = 0.021%; Cr = 0.870%; Mo = 0.104%; V = 0.114%; Cu = 0.963%; B = 30 ppm; Ti = 0.028%; N = 70 ppm (so, Ti/N = 4); Nb = 0.052%; S = 0.024%.

After forging and cooling at a controlled cooling rate of 0.5° C/s between 600°C and 300°C, the obtained structure was entirely composed of **upper** bainite.

No annealing was performed, then, and the mechanical properties of the sample were: tensile strength Rm = 1197 MPa and yield strength $Rp_{0.2}$ = 766 MPa.

Then a deep rolling was performed in the same conditions as the reference example of the present application, at applied loads of 800, 900, 1000, 1100 and 1200 daN during 12 rotations.

For a deep rolling load of 800 daN, crack starting occurred from 2220 N.m and the rupture moment was 5600 N.m. For a deep rolling load of 1200 daN, crack starting occurred from 2150 N.m and the rupture moment was 5880 N.m.

As compared to the reference example, the increase for the crack starting is 12% and for the rupture moment 32%, which is very significant, and at the same levels as the examples in the specification.

Concerning the use of Nb, as explained on page 9, lines 9-12 of Applicants' specification, it can precipitate in the form of carbonitrides in austenite, and therefore improves the hardness of the material. Nb also makes the austenitic grain thinner, which improves the mechanical properties and the fatigue behaviour. It also greatly helps to

obtain upper bainite structure and possibly some granular bainite. Nb makes the bainite field considerably wider and helps to obtain a 100% bainite microstructure at low cooling speeds of less than 3°C/s (0.5°C/s for example), particularly upper bainite and upper + granular bainite.

In the case of the invention, it has appeared to the inventors that, in fact, the presence of Nb was compulsory for obtaining one of the main advantages of the invention, that is allowing to treat the steels of the invention on any forging installation without difficulty and special adaptation.

Normally, if an existing forging installation is designed for treating classical ferrito-perlitic microstructured steels, it is not equipped with forced-air cooling means, since a very low cooling in still air after forging is sufficient for obtaining this kind of microstructure. But normally, obtaining a purely bainitic microstructure implies faster cooling speeds, not obtainable with a mere still air cooling. A requirement of the optimized version of the invention now claimed is that the bainite microstructure be obtained without difficulties on any forging installation, be it equipped with forced-air cooling means or not. (See page 6, lines 1-16 of Applicants' specification.)

The presence of Nb within the required range allows widening of the bainite field. That ensures (see Document 1) that for all slow (3°C/s and less) and long coolings while the steel is between 600°C and 300°C, the bainite field will be directly crossed, without any passage through the ferrite field which would cause a significant proportion of ferrite to remain in the final microstructure.

In Bellus et al., Nb is not compulsory for the following reasons.

1. A 100% bainite structure is not necessary in its case, with 80% being sufficient.
2. A minimum cooling speed of 0.5°C/s is necessary in combination with the other features of the invention it describes, the aim being to place the steel in front of or within the lower bainite field before holding it within this field during at least 2 minutes, in order to obtain a significant proportion of lower bainite, that is at least 15%. (See claim 1 of Bellus et al.)

On the contrary, Applicants' invention requires a maximum cooling speed, that is 3°C/s, the cooling speed being possibly less than 0.5°C/s, for ensuring that the bainite field will be attained, and by its upper part, and so that upper bainite will be privileged in the final 100% bainite microstructure. The supplementary example cited above is clear on that point (cooling rate = 0.5°C/s).

In Bellus et al., without Nb, the presence of any kind of bainite after a very slow cooling of 0.5°C/s or less would even not be obtainable. The structure would be ferrito-perlitic. And even the presence of some Nb could not be sufficient therefore. Note that claim 1 of Bellus et al., if it does not exclude a low cooling speed of 0.5°C/s, requires imperatively that the numerous other process and composition parameters be finely adjusted in order to obtain the desired microstructure with at least 15% of lower bainite and possibly up to 19% perlite/ferrite.

Claim 1 of the invention is by far more simple to perform, with only the following requirements.

1. More precise composition ranges for some elements (not for all elements) than the corresponding ones of Bellus et al., but these ranges can be obtained without particular difficulties, once the steelmaker knows them.
2. A precise range of hot-forging temperature, which is rather high but not particularly narrow, and can be obtained without any problem with the usual inductive heating devices placed ahead the forging devices. Bellus et al. has no particular requirement on the forging temperature, but is more stringent on the following steps of the treatment.
3. A low cooling speed after forging, which is compatible with any cooling device of any forging installation, in that it encompasses cooling speeds obtained by natural cooling in still air. In Bellus et al., in most instances, a forced cooling of the part, by forced air or a more powerful medium, is necessary.

Additionally, Al is not compulsory in Bellus et al., though it is cited in all three examples in significant quantities (0.03-0.04%) and is strongly recommended for

deoxidizing the steel and controlling the size of austenitic grain (see column 3, lines 41-44). In the invention, Al is not compulsory, too, but is indeed absent from the two examples of the application. This provides further evidence that the requirements of Bellus et al. and Applicants' invention are distinct.

V is not compulsory in Bellus et al., and is indeed totally absent in its third example. In the invention, V is not compulsory, too, but all examples contain it significantly. V has an effect of hardening the bainite, which is important since the structure of the steel of the invention is entirely bainitic, while other phases like ferrite can be present in Bellus et al.

Concerning the processes of Bellus et al. and Applicants' invention and the structures they allow to obtain, the enclosed diagrams will show that they are quite different, <u>and unavoidably lead to different products</u>.

In Bellus et al., a totally bainite structure is never explicitly obtained, as evidenced by the three examples which result in at least 80% of bainite. Column 4, lines 12-15 of the reference state that the object of Bellus et al. is to obtain an <u>essentially</u> bainitic structure containing <u>up to less than 20% of ferrite</u>, and with at least 15%, preferably at least 30%, of lower bainite. <u>In the invention as claimed, a 100% bainite microstructure is required, and the composition and process parameters are oriented in accordance therewith</u>. Moreover, these parameters result in the formation of upper bainite or of a mixture of upper and granular bainite (see page 10, lines 22-23 and 29-30, and page 11, lines 7-9), <u>which have different properties</u> than the lower bainite required by Bellus et al.

In Bellus et al., lower bainite is necessary to obtain the required mechanical properties: yield strength higher than 750 MPa, tensile strength 950-1150 MPa and toughness K greater than 25 J/cm² at 20°C.

In the present invention, <u>upper bainite is needed in the perspective of the mechanical reinforcing (deep rolling) operation which will end the process</u>, after which <u>a good fatigue behaviour</u> must remain. See page 11, lines 10-11 of Applicants' specification. <u>Lower bainite would not be efficient on that point</u>. <u>Since Bellus et al. do</u>

not consider a mechanical reinforcement, no such requirement concerning the presence of upper bainite is cited.

The Examiner states that it would be obvious to deeproll the part at locations that are subjected to particularly high levels of stress. This assertion is unfounded since (1) Bellus et al. do not consider a mechanical reinforcement, and (2) Bellus et al. results in a different product, which would not be suitable for the mechanical reinforcement.

Further, the final properties of the products of Bellus et al. and Applicants' invention are not similar, which confirms the vast differences between their making processes, as stressed in the preceding paragraphs.

In Bellus et al., a yield strength Re (or $Rp_{0.2}$) of more than 750 Mpa and a tensile strength Rm between 950 and 1150 Mpa are aimed at, while what is important in the present invention is a good fatigue behaviour after a localised mechanical reinforcement obtained by deep rolling. For obtaining this feature, initial very high mechanical features after forging/cooling and before deep rolling are not always necessary, as can be seen on page 10, lines 12-18, page 10, line 27 to page 11, line 2, page 11, lines 18-25 and page 14, lines 9-12 of Applicants' specification. In these cases, the tensile strengths and, particularly, the yield strengths, are or can be sensibly less than what Bellus et al. requires: for example Re = 550-650 Mpa and Rm = 800-900 MPa (page 10, lines 14-16) and Re = 550 Mpa and Rm = 820 MPa (in the example on page 14). But an absolute requirement for obtaining Applicants required properties is, in combination with the composition of the steel, the 100% bainite microstructure, mostly composed of upper or upper + granular bainite. On the contrary, Bellus et al. tolerates up to less than 20% of perlite/ferrite and insists on a minimal presence of lower bainite rather than upper or granular bainite.

In order to better illustrate these differences, we provide a Supplementary Reference Example, which will show that **a steel made according to Bellus et al. would not be able to fulfil the requirements of Applicants' invention**.

This Supplementary Reference Example was prepared and tested by Applicant, who is also the owner of Bellus et al., during the research of which led to the present invention.

SUPPLEMENTARY REFERENCE EXAMPLE

A steel was prepared with the following composition: C = 0.304%; Mn = 1.349%; Si = 0.257%; S = 0.067%; Ni = 0.215%; Cr = 0.666%; Mo = 0.067%; V = 0.070%; Cu = 0.213%; N = 67 ppm; no Ti, Nb and B were added and their contents were at most traces, under the minimum contents required by the present invention.

This steel differs from the steel of the invention by the absences of Ti, Nb and B, and by a ratio Ti/N = 0. Its Ms temperature is 356°C. It was cast as a squared-section billet.

The billet was heated at 1270°C, then forged between 1270 and 1030°C for obtaining a round blank, from which test samples for the measurement of mechanical properties and fatigue tests after deep rolling were prepared. These test samples were of the classical BALDWIN type, shown in the enclosed Document 2 and intended to simulate the behaviour of the deep rolled fillets of a crankshaft crankpin during fatigue-generating conditions.

Note that the end temperature of 1030°C is less than what the invention requires, but remains in accordance with what Bellus et al. requires, in particular because it is higher than the Ac3 temperature of the steel. (See column 2, lines 58-60 of Bellus et al.) This is another difference between Bellus et al. and the invention.

The blank, after the forging step, was cooled in forced air. At 700°C, the cooling speed was 3.2°C/s and it was kept at this value down to 420°C, which is the temperature called Tm in Bellus et al. Note that this cooling speed in the range 600-420°C was slightly higher than the maximum of 3°C/s required by the invention.

Then the blank was kept between 420°C and 400°C during 12 minutes. 400°C is in accordance with the requirements on the temperature called Tf in Bellus et al., where Tf must be ≥ Tm-60°C.

Then the blank was reheated up to 550°C, according to one of the embodiments of Bellus et al., and cooled in still air.

BALDWIN sample tests were made from the steel so obtained, for microstructural analysis and fatigue measurements.

It appeared that the microstructure was a mixture of 85% bainite, including 20% of lower bainite, and 15% perlite. The requirements of Bellus et al. were fulfilled, but not the ones of the invention which are 100% bainite, preferably upper and granular bainite.

The mechanical properties were $Rp_{0.2}$ = 776 Mpa, Rm = 1034 Mpa, A = 11% (elongation), Z = 34% (reduction of area), K = 45 J/cm² (toughness). All these properties were in accordance with the results aimed for in Bellus et al.

Then, the BALDWIN test samples were machined in accordance with the enclosed Document 2 and the passage on page 12, lines 21-23 of the present application, and deep rolled in accordance with the passage on page 12, lines 21-25. The angle was 35° and the maximum applied load 900 daN. 3 rotations were used to raise the load from 0 up to 900 daN, a load which was kept at this value during 6 rotations, then the load was brought back to 0 daN within 3 rotations. Note that these conditions were much more severe than the ones of Bone, where the nominal load is applied during one turn only.

The fatigue test results were:

- crack starting momentum: 2100 N.m;

- rupture momentum: 4230 N.m.

These results are of similar quality to the ones of the reference sample of the present application (respectively 2090 and 4050 N.m, see page 12, lines 26-31), which had a ferrito-perlitic structure.

Thus, the use of a steel having a composition according to what is recommended by Bellus et al., which undergoes a forging, a cooling and a thermal treatment according to Bellus et al., gives a final structure which is not entirely bainitic, containing only 85% of bainite (including 15% of lower bainite) and a little less than 15% of ferrite, the remaining being perlite. This structure gives non-improvement to the fatigue properties obtained after deep rolling in the same conditions as the reference steel. So, the solution of the technical problem, the invention aimed at solving, did not lie in the use of a steel produced according to Bellus et al., even when associated with a deep rolling.

The solution to this technical problem, that is the combination of all composition and process features of claim 1, resulted in an increase of the fatigue properties in a significant manner, as discussed in the application (page 13, lines 14-16, page 14, lines

17-19) : +20 to +35% in the described examples on crack starting moments and rupture moments.

These better results, as compared to the steels of Bellus et al. treated as above and to the reference example of the application, show that the particular 100% upper bainite or upper bainite + granular bainite structure obtained if all requirements of the invention as claimed are fulfilled, is absolutely essential for the invention.

It appears now that such a structure is better adapted to local mechanical reinforcements than ferrito-perlitic structures (like the reference example of page 12 38MnSiV5 type, or the new reference example which is not entirely bainitic and has ferrite and lower bainite). The passage on page 13, lines 17-29 of Applicants' specification, particularly lines 25-29, is confirmed. The ferrite which is present in all reference examples is more softened than the upper bainite of the steels made according to the invention, which harden when they undergo fatigue stresses.

Enclosed herewith are also Documents 3 and 4 which demonstrate the differences between the thermomechanical treatments of Bellus et al. and the invention, and further illustrate these differences.

For these reasons, the invention of claims 1, 7-13 and 15-17 is clearly patentable over the cited combination of references. [Claim 6 has been cancelled.]

Therefore, in view of the foregoing amendments and remarks, it is submitted that each of the grounds of rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

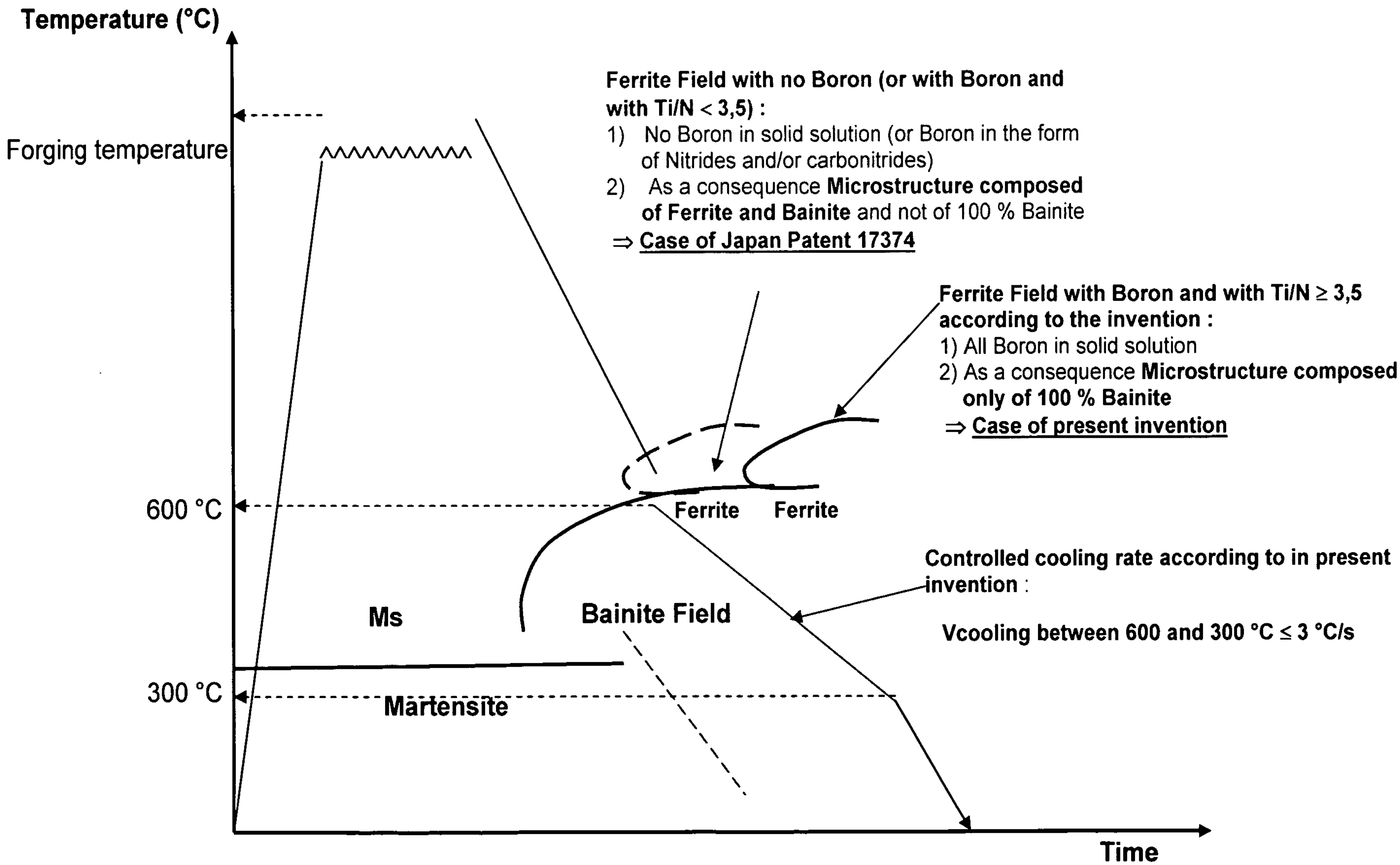
Respectfully submitted,

Herve MICHAUD et al.

By: ______________________
Amy E. Schmid
Registration No. 55,965
Attorney for Applicants

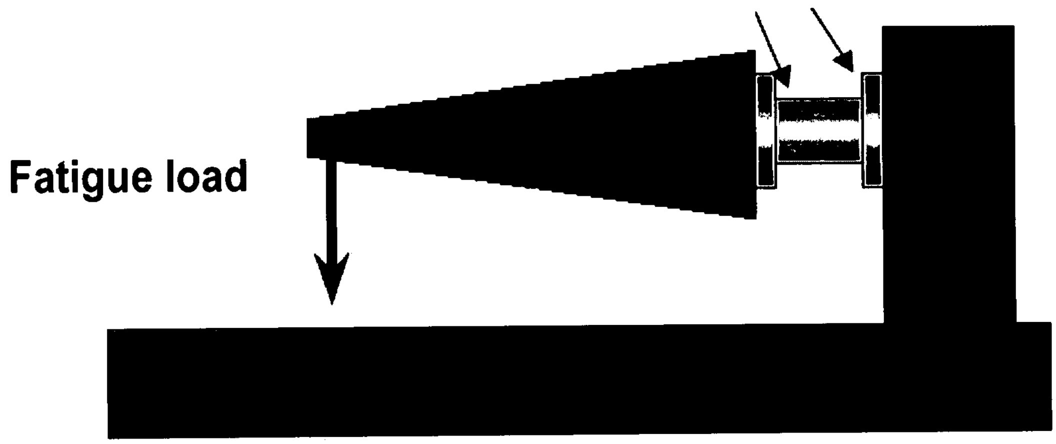
AES/nrj
Washington, D.C. 20006-1021
Telephone (202) 721-8200
Facsimile (202) 721-8250
August 14, 2007

DOCUMENT 1
Influence of Boron and Ti/N ratio on microstructure of present invention
CCT curves after hot forging

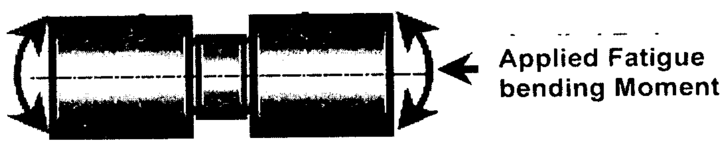


DOCUMENT 2

Test piece with deep-rolled fillets on a component



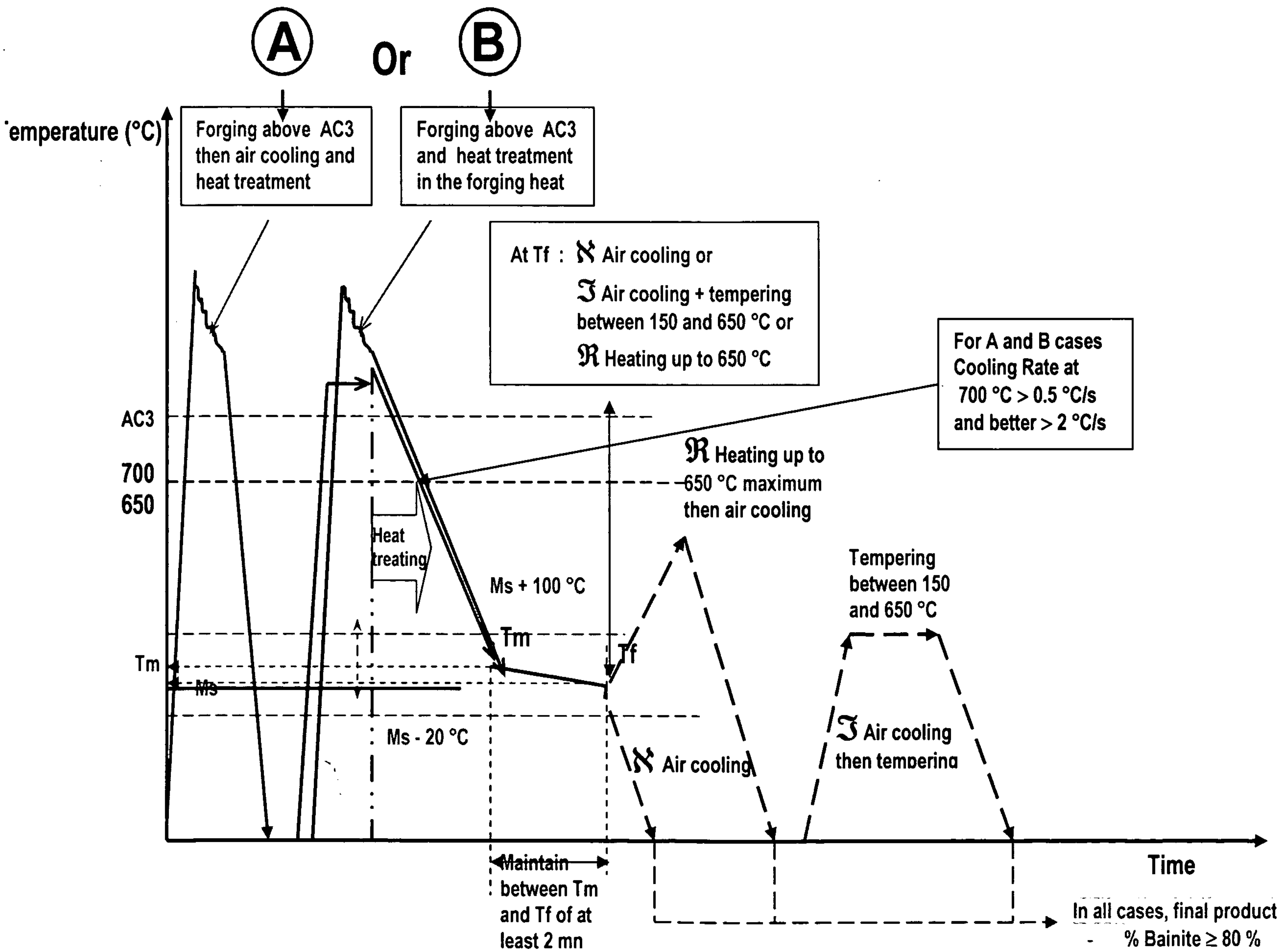
Fatigue testing device used to simulate fatigue behavior of deep rolled fillets on a component



Test piece used to carry out bending fatigue tests on deep rolled fillets on a component

DOCUMENT 3 Comparison between US'706 Patent and present Patent application Process routes

1) Process Route according to US'706

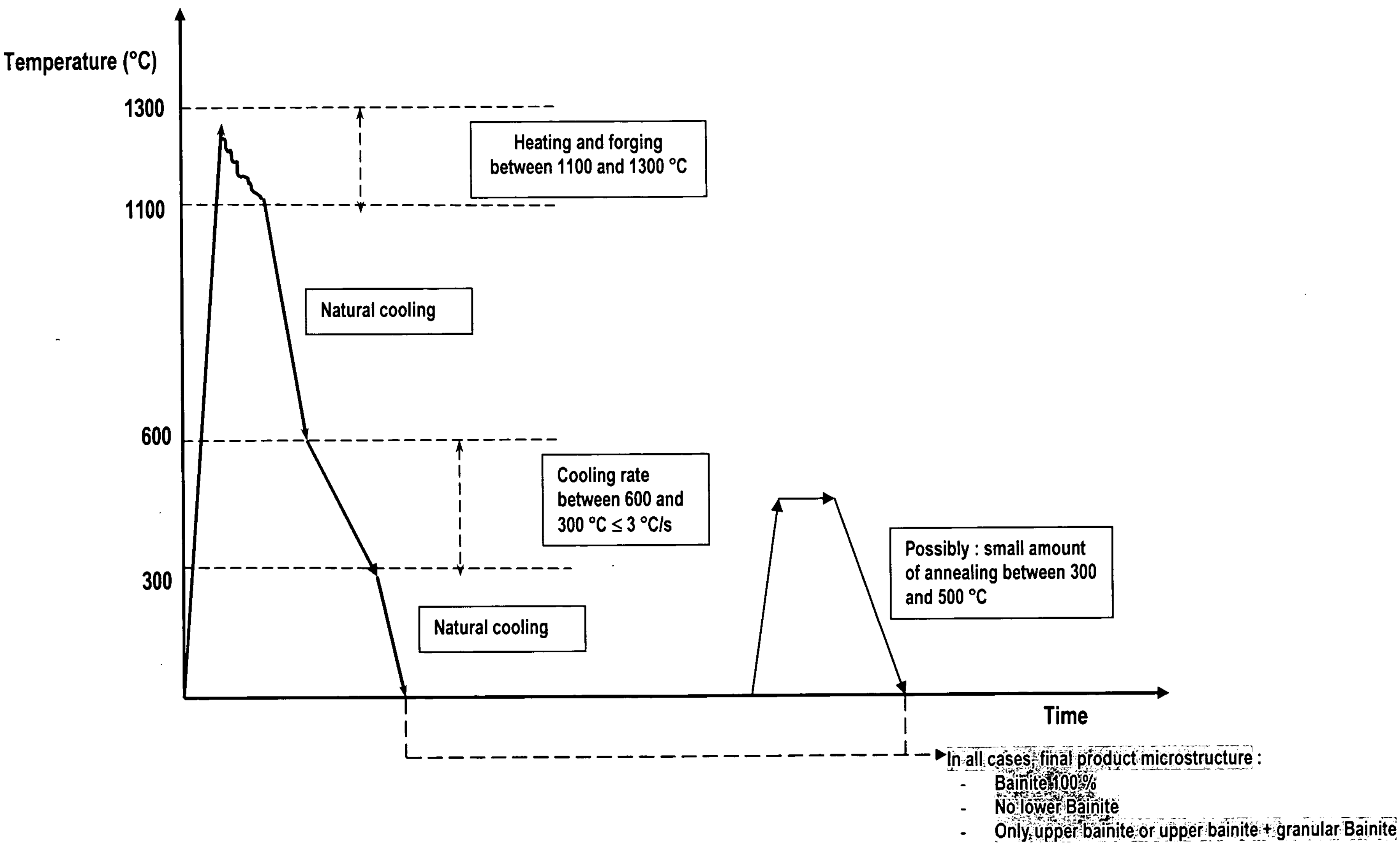


In all cases, final product microstructure :

- % Bainite ≥ 80 %
- with lower Bainite ≥ 15 and better ≥ 30 %
- and Ferrite < 20 %

DOCUMENT 4 Comparison between US'706 Patent and present Patent application Process routes

2) Process Route according to present application



Kilogram-force

From Wikipedia, the free encyclopedia

The deprecated unit **kilogram-force** (**kgf**, often just **kg**) or **kilopond** (**kp**) is defined as the force exerted by one kilogram of mass in standard Earth gravity. Although the gravitational pull of the Earth varies as a function of position on earth, it is here defined as exactly 9.80665 m/s². So one kilogram-force is by definition equal to 9.80665 newtons. [1]

The kilogram-force has never been a part of the International System of Units (SI), which was introduced in 1960. The SI unit of force is the newton.

Prior to this, the unit was widely used in much of the world; it is still in use for some purposes. The thrust of a rocket engine, for example, was measured in kilograms-force in 1940s Germany, in the Soviet Union (where it remained the primary unit for thrust in the Russian space program until at least the late 1980s), and it is still used today in China and sometimes by the European Space Agency.

It is also used for tension of bicycle spokes, for torque measured in "meter-kilograms", for pressure in kilograms per square centimeter, for the draw weight of bows in archery, and to define the "metric horsepower" (PS) as 75 m·kgf/s. [1]

Grams-force and kilograms-force were never well-defined units until the CGPM adopted a *standard acceleration of gravity* of 980.665 cm/s² for this purpose in 1901, though they had been used in low-precision measurements of force before that time.

A **tonne-force**, **metric ton-force**, **megagram-force**, or **megapond** (**Mp**) is 1000 kilograms-force.

The **decanewton** (**daN**) is used in some fields as an approximation to the kilogram-force, being exactly rather than approximately 10 newtons.

Units of force

	Newton (SI unit)	Dyne	Kilogram-force (Kilopond)	Pound-force	Poundal
1 N	≡ 1 kg·m/s²	= 10^5 dyn	≈ 0.10197 kp	≈ 0.22481 lb_f	≈ 7.2330 pdl
1 dyn	= 10^{-5} N	≡ 1 g·cm/s²	≈ 1.0197×10^{-6} kp	≈ 2.2481×10^{-6} lb_f	≈ 7.2330×10^{-5} pdl
1 kp	= 9.80665 N	= 980665 dyn	≡ g_n·(1 kg)	≈ 2.2046 lb_f	≈ 70.932 pdl
1 lb_f	≈ 4.448222 N	≈ 444822 dyn	≈ 0.45359 kp	≡ g_n·(1 lb)	≈ 32.174 pdl
1 pdl	≈ 0.138255 N	≈ 13825 dyn	≈ 0.014098 kp	≈ 0.031081 lb_f	≡ 1 lb·ft/s²

The value of g_n as used in the official definition of the kilogram-force is used here for all gravitational units.

References

1. ^ *a* *b* *Guide for the Use of the International System of Units (SI)*, NIST Special Publication 811, 1995 p. 51 [1] (http://physics.nist.gov/Pubs/SP811/appenB8.html#K)

External link

- BIPM SI brochure, chapter 2.2.2. (http://www1.bipm.org/en/si/si_brochure/chapter2/2-2/2-2-2.html)

Retrieved from "http://en.wikipedia.org/wiki/Kilogram-force"

Categories: Units of force | Non-SI metric units

How Many? A Dictionary of Units of Measurement

D

D
the Roman numeral 500.

D-
an incorrect symbol for the metric prefix deka- or deca-, seen in combinations such as DL (dekaliter) or DTH (dekatherm). The correct prefix is **da-**.

dag
symbol for the dekagram (10 grams; see entry below), a common metric unit of mass.

daily value (DV)
a unit of nutrition used in the United States. The U.S. Food and Drug Administration establishes recommended daily amounts of various nutrients, both "good" ones like vitamins and "bad" ones like fat and sodium. These so-called daily values are based on a hypothetical person, male or female, who requires a diet of 2000 Calories per day. The results are approximate at best, since nutritional needs vary with age, sex, and other factors. Food packages generally carry nutritional lables specifying the amount of each nutrient contained in a standard serving, expressed as a percentage of the daily value (%DV). A table of the official daily values for each nutrient is provided.

daktylos
an ancient Greek unit of distance equal to a finger width, about 19 millimeters or 0.75 inch. There were 16 daktylos in the pous, the Greek foot, and 24 in a pechys (cubit). This unit was the Greek predecessor of the Roman digit (see below).

dal or daL
symbol for the dekaliter (10 liters; see entry below), a common metric unit of volume.

dalton (Da or D)
an alternate name for the unified atomic mass unit (u or amu). The dalton is often used in microbiology and biochemistry to state the masses of large organic molecules; these measurements are typically in kilodaltons (kDa). It seems necessary to have such a unit, since "kilo-amu" would be such a clumsy name. The SI accepts the dalton as an alternate name for the unified atomic mass unit and specifies Da as its proper symbol. The unit honors the English chemist John Dalton (1766-1844), who proposed the atomic theory of matter in 1803.

dam
symbol for the dekameter (10 meters; see entry below), a metric unit of distance.

dan
a traditional Chinese weight unit, previously spelled **tan** in many English works. During the European colonial era the unit was equal to 100 catties or 133.333 pounds. In modern China the dan is equal to 100 jin, which is exactly 50 kilograms (110.231 pounds). The dan is the Chinese equivalent of the European quintal or hundredweight.

daN
symbol for the decanewton or dekanewton (see below under dekanewton), a common metric unit of force.

Danjon scale
a scale measuring the brightness (or rather, the darkness) of lunar eclipses, devised by the French astronomer André Louis Danjon (1890-1967). A table is provided.

daraf
a unit of electrical elastance, which is the ability of an electric potential to charge a capacitor. The daraf is equal to one volt of potential per coulomb of charge (V/C). The name of the unit is "farad" spelled backwards, because the elastance, in darafs, is 1 divided by the capacitance in farads. This unit is not recognized as part of the SI.

darcy
a CGS unit of permeability. Permeability is the extent to which a solid allows the flow of a fluid. This flow depends on the properties of the solid and also on the dynamic viscosity of the fluid and the difference in pressure driving the flow. One darcy is the permeability of a solid through which one cubic centimeter of fluid, having a viscosity of one centipoise, will flow in one second through a section one centimeter thick and one square centimeter in cross section, if the pressure difference between the two sides of the solid is one atmosphere. It turns out that permeability has the same units as area; since there is no SI unit of permeability, square meters are used. One darcy is equal to about 0.98692×10^{-12} square meter. The unit is named for a French scientist, H. Darcy (1803-1858), who did pioneering work in the study of permeability.

stated in kelvins, not in degrees Kelvin.

degree KMW (°KMW)
a unit used in Austria to measure the sugar content of must, the unfermented liquor from which wine is made. One degree KMW is roughly equivalent to 1% sugar by weight or 5° Oe; for the exact conversion see below under degree Oeschle. KMW is an abbreviation for Klosterneuburger Mostwaage (Klosterneuburg Must Scale).

degree Lovibond (°L)
a unit used in the U.S. to measure the color (really the darkness) of beer and honey. The scale is open-ended, but most readings fall between 1 (a very light gold, or yellow) and 25 (a very dark brown). A good description of the scale, with comments on other units in use, has been posted by pdlab.com.

degree MacMichael (°McM)
a unit used to measure the viscosity, or thickness, of chocolate. Typical values range from around 60 °McM (very thin chocolates suitable for pouring into molds) to around 190 °McM (very thick chocolates suitable for hand dipping or forming around a center). A MacMichael viscometer is used to make the measurement.

degree Oechsle (°Oe)
a unit used in Germany and Switzerland to measure the sugar content of must, the unfermented liquour from which wine is made. One degree Oechsle (or Öchsle) is roughly equivalent to 0.2% sugar by weight. This unit is related legally to °KMW by the formula °Oe = °KMW * ([.022 * °KMW] + 4.54).

degree Plato (°P)
a unit measuring sugar content, especially of the wort, the unfermented liquour from which beer is made. Named for a German chemist, one degree Plato represents a sugar content equivalent to 1% sucrose by weight. Not all the sugar in a wort is sucrose; the unit standardizes the measurement to the sucrose equivalent. The reading is made with a device called a saccharometer. The **degree Balling** is a somewhat older unit equivalent (approximately) to the degree Plato. In Europe, beer is often taxed either by the degree Plato or by the actual alcohol content. There is no precise conversion between these quantities, but for tax purposes it is often assumed that 1% alcohol (1 degree [6], see above) is equivalent to 2.5 degrees Plato; that is, 1 degree Plato is legally equivalent to 0.4% alcohol.

degree Quevenne (°Q)
a unit measuring the density of milk. 1 °Quevenne represents a difference in specific gravity of 0.001, so, for example, 20 °Q milk has specific density 1.020.

degree Rankine (°R)
a traditional unit of absolute temperature. 1 °Rankine represents the same temperature difference as 1 ° Fahrenheit, but the zero point of the scale is set at absolute zero. This means the Rankine temperature is 459.67° plus the Fahrenheit temperature. 1 °Rankine is equal to exactly 5/9 kelvin. The unit is named for the British physicist and engineer William Rankine (1820-1872).

degree Réaumur (°r)
a unit of temperature formerly used in continental Europe. The Réaumur temperature scale is named for the French scientist René-Antoine Ferchault de Réaumur (1683-1757). It is similar to the Celsius scale in having its zero point at the freezing temperature of water, but the interval between the freezing and boiling temperatures of water equals 80 °r instead of 100 °C. Therefore, 1 °r equals 1.25 °C or 2.25 °F.

degree Soxhlet-Henkel (°SH)
a measure of the acidity of milk. Each degree Soxhlet-Henkel is equivalent to 0.0225% lactic acid in the milk. Normal values are around 7.

degree Therner (°Th)
a measure of the acidity of milk. Each degree Therner is equivalent to 0.009% lactic acid in the milk. Normal values are around 17.

degree Twaddle (°Tw)
a unit measuring the specific gravity of liquids denser than water. 1 °Twaddle represents a difference in specific gravity of 0.005 or 1/200, so a liquid of specific gravity S is measured at 200(S - 1) °Tw. For milk, 1 °Twaddle equals 5 °Quevenne (see above).

deka- (da-)
a metric prefix meaning 10, taken directly from the Greek word for ten, *deka*. The Latin spelling deca- is also used (see deca-, above). Although the U.S. National Institute for Standards and Technology recommends deka-, deca- is seen frequently in American publications. The spelling deca- is also used in French and in other languages where "k" rarely occurs in the middle of a word. Regardless of spelling, da- is the official symbol. (The symbol dk- for deka- is incorrect, but it is seen fairly often.)

dekagram or decagram (dag)
a common metric unit of mass, the dekagram is frequently used in European food recipes. One dekagram is equal to 10 grams, 0.01 kilogram, or 0.352 739 66 ounce. The symbol **dkg** sometimes used for this unit is

incorrect.

dekaliter or decaliter (daL or dal)
a metric unit of volume equal to 10 liters and comparable to the English peck. The dekaliter is equal to about 2.641 72 U.S. liquid gallons, 1.135 10 U.S. pecks, or 2.199 69 British imperial gallons (1.099 85 British pecks). The symbol **dkL** sometimes used for this unit is incorrect.

dekameter or decameter (dam)
a common metric unit of distance equal to 10 meters (about 32.8084 feet). The symbol **dkm** sometimes used for this unit is incorrect.

dekanewton or decanewton (daN)
a fairly common metric unit of force equal to 10 newtons. The dekanewton is equal to 1 megadyne, to 1.019 716 kilograms of force (kgf) or kiloponds (kp), to 2.248 09 pounds of force (lbf), and to 72.3301 poundals. In engineering, the dekanewton is a convenient substitute for the kilogram of force or kilopond, since it is nearly equal to those units.

dekan
a unit of angle measure equal to 10° or 1/36 circle. The ancient Egyptians divided the circle of the Zodiac into 36 divisions, which the Greeks called dekans. The unit is still used occasionally in astrology, where one dekan equals 1/3 sign.

dekare or decare
a metric unit of area equal to 10 ares, that is, 1000 square meters or 0.1 hectare. In English units, the dekare equals approximately 10 763.91 square feet, 1195.99 square yards, or 0.247 105 acres. Various traditional units of land area have been identified with the dekare, including the Middle Eastern dunum (see below), the Norwegian mål, the Greek stremma, and the Vietnamese cong.

dekatherm or decatherm (DTH)
a unit of energy equal to 10 therms, 1 million Btu, or about 1.055 057 gigajoules (GJ). This unit is used in the energy industry as a synonym for the million-Btu (MM Btu).

demal (D)
an obsolete unit of concentration in chemistry. From 1901 to 1964, the liter was officially defined to be exactly 1.000 028 cubic decimeter. During this period, there was a small difference between measuring concentration in moles per liter and in moles per cubic decimeter. Concentration in moles per liter is called molar, while concentration in moles per cubic decimeter was called demal. This distinction has now disappeared along with the awkward definition of the liter. The former conversion was 1 demal = 1.000 028 molar.

demi-
a traditional prefix meaning 1/2. The prefix is derived from the Latin *dimedius*, meaning a cut in the middle of something.

demi [1]
a half bottle of wine (375 milliliters).

demi [2]
an informal French unit of volume for beer, generally equal to 250 milliliters (1/4 liter). The unit was originally a half pint (*demipinte*).

demisemiquaver
a unit of relative time in music equal to 1/32 whole note or 1/64 breve.

denaro
a traditional Italian weight unit equal to 24 grani; its size varied from about 1.1 grams to 1.25 grams.

denier [1]
a traditional unit of yarn density. One denier is the density of a thread having a mass of 1 gram per 9 kilometers of length. The metric unit of yarn density is the tex; 1 denier equals 1/9 tex or 10/9 decitex.

denier [2]
a traditional French weight unit, comparable to the English pennyweight. Like the pennyweight, the denier is equal to 24 grains (1.275 grams). This unit was also called the **scrupule**.

dessertspoon or dessertspoonful (dsp or dssp)
a unit of volume sometimes used in food recipes. The dessertspoon is equal to 2 teaspoons; this is roughly equivalent to 10 milliliters in the U.S. In the metric world, a measuring spoon holding exactly 10 milliliters is often called a dessertspoon.

dessiatina
a traditional unit of land area in Russia equal to 2400 square sadzhens. By coincidence, this makes the dessiatina very nearly the same as a hectare: it equals about 1.0925 hectare or 2.6996 acres.

deuce
an old English word for two, derived from the old French *deus* (now spelled *deux*). The word survives as the